ASTR 288C – Lecture 1

Monday, 31 August 2009

Introduction

Introduction to the Class

Time: 3:30 – 5:15 PM on Mondays
Place: CSS 1109

Office Hours: by appointment

Instructor:

Stephen Holland, Stephen.T.Holland@nasa.gov, +1 301–286–7063

Textbooks:

None

Course Web Site:

To be determined

Homework:

Homework will be assigned for each class and handed out at the beginning of each lecture. Unless otherwise indicated all homework is due at the start of the next week's lecture. All homework assignments will carry the same weight for the final grade, unless otherwise indicated.

The class will be split into a lecture portion and a lab portion. The first half of each class (approximately 45 minutes) will be a lecture. The second half of each class (approximately 45 minutes) will be lab time. Some classes will be weighted more heavily towards either lecture or lab work depending on the subject matter.

There will be homework assignments and a research project. Homework will be based on the material in the lecture and lab work. The research project will be based on the skills that you learn in this course. In this class you will be required to do things like researching a topic on the Web, making a presentation to the class, writing a short report, downloading and analysing data sets, and learning some basic software that is used in astronomy.

There will be no exams in this course. Homework will be worth 60% of the final grade. The lowest-grade homework assignment will not be counted toward the final grade. The research project will be worth 40% of the final grade. A written report on your research project must be handed in by the end of the final class (7

Dec 2009). You will also be required to make a short presentation to the class based on your research project.

Requirements

ASTR 288C is aimed at a second-year level. Students should be familiar with first-year physics and maths, and have some basic knowledge of astronomy. The course is intended to teach some practical skills that will be useful when doing astronomical research. This class is not going to delve into detailed analysis methods that are specific to certain data sets, but rather will cover broad principles and try to provide the tools needed so that one can quickly learn to use task-specific tools to analyse any given data set.

There will be an emphasis on using the Web to find information, and on presenting that information. There will also be practical data analysis projects that will introduce basic concepts that are common to all data reduction.

Academic Integrity

- Students are encouraged to collaborate and discuss lectures and course material. Homework is to be done individually and each student must hand in unique work. Copying from another student is not acceptable. Any homework that is found to be a copy of other homework will receive a grade of 0.
- Students must comply with the Honour Pledge of the University of Maryland as listed on the Student Honour Council Web site at http://www.studenthonorcouncil.umd.edu/ .
- Academic dishonesty consists of cheating, fabrication, facilitation, and plagiarism. See the above Web site for complete descriptions. These behaviours will not be tolerated.

Scientific Ethics

Integrity is vital to scientific research. Science is based on the idea that research is done honestly and reported truthfully. There are several checks and balances built into the culture of scientific research to ensure that this happens, but the ultimate responsibility for carrying out honest and truthful research rests with the individual scientist. Some examples of unethical behaviour are plagarism, falsifying data, deliberate misinterpretation of results, and failure to give appropriate credit to previous work.

One check on scientific honesty is that all researched should be published in peer-reviewed journals. Peer-review is a process whereby an article is examined by at least one scientist who is working in the field to see if the results are reasonable. This is done to prevent dishonest research from being published and to detect honest mistakes. Scientific journals will usually not publish an article that has not been peer reviewed.

As second check is that other scientists will usually attempt to duplicate most research. Results that can not be duplicated are usually considered to be wrong. A good example of this is the claim by one research group that cold fusion was achieved in the 1980s. No other group was able to reproduce this result, and it is now generally accepted that the original cold fusion work was wrong.

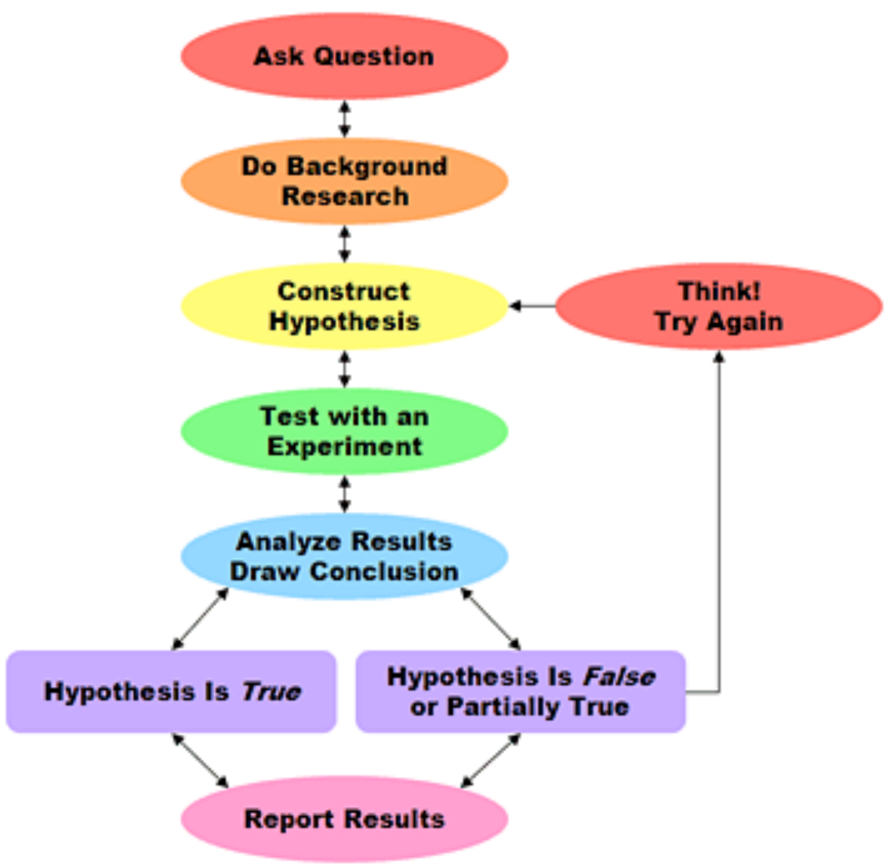
Scientists who are found to have plagiarized other people's work, falsified their data, made false claims in published work, failed to credit previous work, or otherwise violated academic ethics usually lose their careers.

The Scientific Method

The scientific method is a way to ask and answer questions. It is the fundamental foundation of all science, including astronomy. The steps of the scientific method are

- Observe a phenomena
- Construct a hypothesis to explain what you have observed
- Perform an experiment to test the hypothesis by trying to observe something that it predicts
- If the prediction is not observed then reject the hypothesis and start again
- If the prediction is observed then test another prediction
- Communicate your results to the scientific community and the general public

The scientific method can be illustrated as a flow chart.



The scientific method's strongest advantage is that it is objective. It only deals with what can be observed and tested in a repeatable way. This means that science is not dependent on one person's interpretation of events. It also means that a well-established theory can be overturned if an observation is made that contradicts that theory.

An example of this occurred in the 1990s. Einstein's general theory of relativity predicts that there is a cosmological constant that acts to accelerate the expansion of spacetime. Before 1998 there was no evidence to support the existence of this constant, so astronomers assumed that it must have a value of $\Lambda = 0$ (i.e., no acceleration). In 1998 a research ground found that their observations of supernova showed that the expansion of the Universe is actually acceleration, which means that the cosmological constant is non-zero. This was their hypothesis. Since then other groups have tested this hypothesis by repeating the supernova observations, and by performing other measurements of the cosmological constant, and have found that their results agree with the hypothesis that $\Lambda \neq 0$. This has now become part of the standard cosmological model. However, astronomers continue to test this hypothesis, and it is possible that more changes will need to be made in the cosmological model in the future.

It is important in astronomy to investigate unusual results because they may lead to a new understanding of some part of the Universe. Never reject scientific results because they are not what you expected them to be.

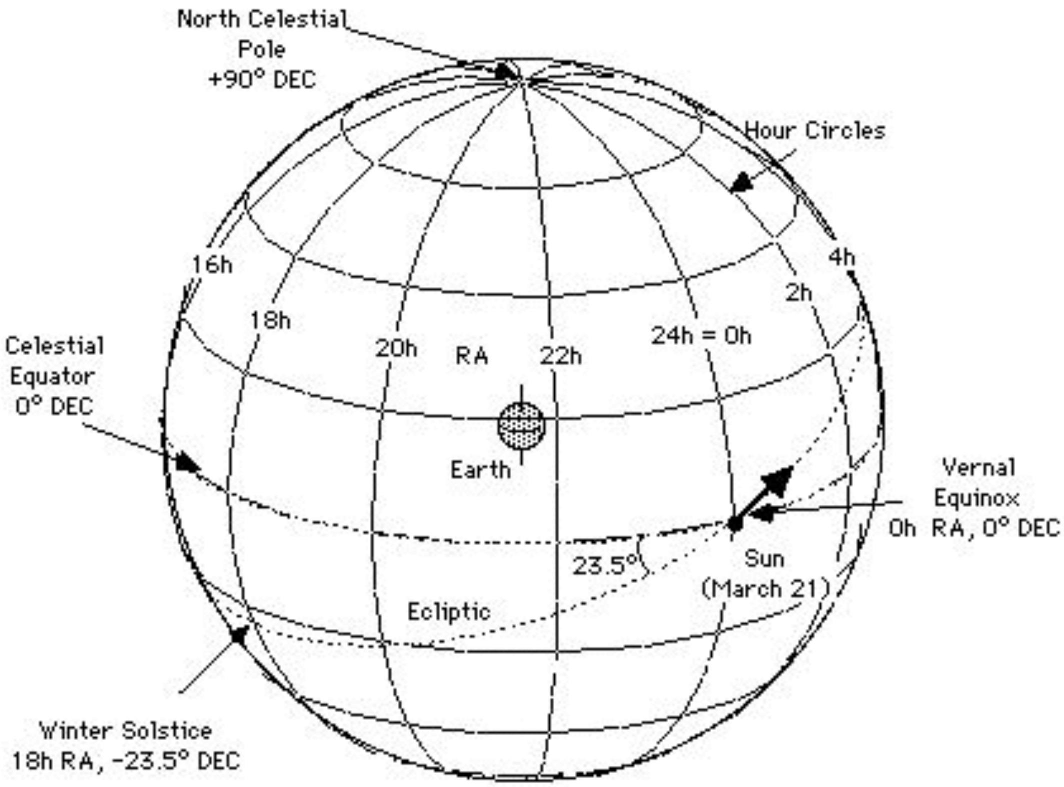
Basic Astronomy

Astronomical Coordinates

There are several astronomical coordinate systems, including celestial equatorial, galactic, and ecliptic. The most commonly used is **celestial equatorial coordinates**.

Celestial equatorial coordinates are essentially a projection of the Earth's longitude and latitude onto the sky. The equivalent of longitude is called **right ascension** (also called $\boldsymbol{\alpha}$). This is the angular distance, measured in hours, minutes, and seconds of time, eastward along the celestial equator. The units run from $00^h00^m00^s$ to $23^h59^m59^s$. One hour of right ascension is the equivalent of 15° in angle. The equivalent of latitude is called **declination** (also called $\boldsymbol{\delta}$). This is the angular distance from the celestial equator (which is a projection of Earth's equator onto the sky). Declination runs from 00°00'00" at the celestial equator to

+90°00’00” at the north celestial pole and −90°00’00” at the south celestial pole.



Because of precession of the Earth’s axis celestial equatorial coordinates also precesses. This means that the coordinates of a source in the sky will slowly shift with time. Therefore, it is important to specify the epoch that the coordinates are defined for. The usual convention is to use 50-year increments when defining coordinate epochs. The current epoch is 2000.0. An example is the celestial coordinates of Spica are RA, Dec = $13^h25^h11.579^s$, −11°09’40.76” (2000.0).

Magnitudes

Brightness in astronomy is often given on the **magnitude scale**. The magnitude scale is logarithmic, and backwards, and is kept primarily for historical reasons. A magnitude 1 star is approximately 2.5 times brighter than a magnitude 2 star. A magnitude 2 star is approximately 2.5 times brighter than a magnitude 3 star, and so on. Sixth magnitude is the faintest start that a person with normal eyesight can see at a dark site. The formula for computing the apparent magnitude of a source given its measured flux density is

$$m = K - 2.5 \log_{10}(f)$$

where m is the **apparent magnitude**, f is the flux density, and K is a zero point. The value of the zero point depends on the wavelength that the observation was taken at, and on the physical units of f. Apparent magnitude is the observed magnitude

The magnitude scale is mostly used in optical astronomy, although it is sometimes used for ultraviolet and infrared observations. Other sub-fields of astronomy (radio, *X*-ray, &c.) tend to use fluxes or flux densities directly instead of the magnitude scale.

The **absolute magnitude** of a source is the magnitude that the source would appear to have at a distance of 10 parsecs. Absolute magnitude is given by

$$M = m + 5 - 5 \log_{10}(d)$$

where M is the absolute magnitude, m is the apparent magnitude, and d is the distance in parsecs.

Lab Work

Basic Computing

Most scientific computing is done using some variant of the unix operating system. Learning unix is essential for a career in modern astronomy. One does not need to become unix guru, but it is almost impossible to do astronomical research without being comfortable working in a unix environment.

Learning unix takes years. Fortunately, it is an incremental process and one can start slowly. Unfortunately unix is a rather unforgiving operating system, so take care when learning new commands, and even with using ones that you are familiar with. For example, the default behaviour for the **rm** command is to delete all of the listed files without warning the user, or asking for confirmation. There is no way or recovering a file that has been deleted using the **rm** command.

The help system on a unix system is accessed using the **man** command. Typing **man man** will give you the help pages for the **man** command. Unix man pages can be a bit cryptic, and much of the information is not relevant when first learning unix. There are many tutorials on the Web that can help one learn unix. These can be found by a Google search, but http://www.ee.surrey.ac.uk/Teaching/Unix/ is quite nice.

Here are some basic unix commands. Please be aware that unix is case sensitive. For example, the command **Man** is not the same as the command **man**.

Listing the files in a directory is done using the **ls** command.

Changing directories is done using the **cd** command. For example, changing to a subdirectory called fred is done by typing **cd fred**.

Copying files is done using **cp**. For example copying fred.dat to a new file called ethel.dat is done using **cp fred.dat ethel.dat**. *If* ***ethel.dat*** *already exists it will be overwritten*. Use the "–i" flag to get a prompt when a file is going to be overwritten, for example, **cp –i fred.dat ethel.dat**.

Renaming files is done using **mv**. This will overwrite existing files, so use the "–I" option to get a prompt when a file is going to be overwritten.

There are several ways to edit a file. One of the most powerful editors in unix is **emacs** but the learning curve can be rather steep. Use whichever editor you are comfortable with.

1. Learn to log onto the computers and access the Department's network. Be sure that you can log into your ASTR288C account.
2. Practice some basic unix skills. There is a nice unix tutorial at http://www.ee.surrey.ac.uk/Teaching/Unix/. Work though these tutorials over the next two weeks.
3. Do the following today
   a. Log into your home directory
   b. Learn to use the **man** command. This is the unix help system. Start with **man ls**.
   c. List the files in this directory (**ls** command)
   d. Create a subdirectory called astr288c (**mkdir** command)
   e. Create a file that contains a list of the files in your home directory (use your favourite editor, or **ls –1 ~ > files.txt**. Understand what this command does, if you use it).
   f. Print the files.txt file that you created. *Hand this in with your homework.*
   g. Find an astronomical image on the Web and print it. *Hand this in with our homework. Say what Web site the image is from.*